Cross-section measurements of the ^{29}Si$(p,2\alpha)^{22}$Na reaction by residual activity

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A stacked-foil method was used to obtain the excitation function of the ^{29}Si$(p,2\alpha)^{22}$Na ($Q = -14273.7(5)$ keV) reaction for energies near the threshold. Measurements by residual activity were performed in eight silicon foils irradiated with a 24 MeV proton beam. A careful study about the existence of some impurities of ^{23}Na in the silicon sample (which could affect the results due to the fact that the magnitude of the ^{23}Na neutron capture cross section is much larger than the ^{29}Si$(p,2\alpha)^{22}$Na cross section) was made using ($n_{thermal}$,γ) reaction with a thermal neutron beam with a flux of 10^{13} neutron/cm^2s. The ratio of the number of ^{23}Na and silicon atoms in a silicon sample was calculated as being $0.570(61)\cdot10^{-12}$.

The study of reactions induced by protons with energies near the threshold and that presents a very small value for the cross-section, order of μb, is very scarce in the literature. These data can give a better understanding about the formation of the compound nucleus and the existence of structures, clusters, inside the nuclei. In particular, $(p,2\alpha)$ reactions are usually studied in energies far from the threshold. This situation can be understand taking into account the magnitude of the cross-sections and the experimental difficulties where the presence of few impurities can produce ambiguous data. The nuclide ^{22}Na (half-life of 2.602 years) originated from the $(p,2\alpha)$ reaction. The ^{22}Na decays by electron capture to ^{22}Ne and it is identified by the characteristic gamma line of 1274 keV.

The energy of the proton beam was monitored by putting a cooper foil in front of the silicon samples. The energy was obtained from the ratio of the ^{62}Zn and ^{65}Zn activities coming, respectively, from the ^{63}Cu$(p,2n)$ and ^{65}Cu$(p,2n)$ reactions. The peaks were fitted using a covariant least-squares method. The results for the proton beam energy and the calculated cross sections are presented in Table 1 for the various silicon foils.

foil	proton energy (MeV)	cross section (μb)
1	23.69(14)	66(3)
2	22.87(14)	15.4(9
3	22.02(15)	1.0(4)
4	21.20(15)	25.4(9)
5	21.15(15)	9.0(8)
6	19.32(16)	2.1(5)
7	18.96(16)	4.1(4)
8	16.50(18)	0.92(28)

Table 1: Results for the cross section of the ^{29}Si$(p,2\alpha)^{22}$Na reaction. The first column is the number of the silicon foil and the second is the energy of the incident proton beam.

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